



SPECTROGRAPHIC NITROGEN DETECTOR

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This device is used to detect a low level of nitrogen contamination in a stream of helium gas. The system operates on the principle of detecting the characteristic spectral emission lines of gaseous nitrogen. The stream of helium gas is fed through a transparent cell in which the gas is excited to the point of light emission. The next step is to analyze the light into its component wavelength and transmit to the detector only a narrow band of wavelengths. The choice of this wavelength determines which substance the system responds to. The wavelength analysis is accomplished with a grating monochromator. The next step is to detect an intensity level (basically a photometer). In this case a photomultiplier was used. The combination of the high resolution of the grating monochromator and the high sensitivity of the photomultiplier make it possible to detect low levels of a contaminant while ignoring a large concentration of the pure gas and its characteristic emission lines.

A working model of the system has been built to test the principle, to get an idea of the sensitivity available, and to determine experimentally the optimum wavelength to use. The system was set up with a contamination of 50 parts per million by volume of nitrogen gas in a stream of ultrapure helium. Figure 1 shows the apparatus used. A flow of about 3 cfh of either pure helium or helium with 50 ppm nitrogen was used.

As the gas was flowing the wavelength setting on the monochromator was scanned at a constant rate. The detector output was then displayed on a chart recorder so as to plot the wavelength spectrum from the source. In this way, various emission lines from helium and bands from nitrogen were observed.

It was found experimentally that the molecular band from N_2^+ at 3314 Å° (described as $^2\Sigma \rightarrow ^2\Sigma$ in molecular spectroscopy¹) gave a clear nitrogen signal. A helium line nearby at 3288 Å° gave the nearest competition to this line. Figure 2 shows a wavelength scan in this region. It is shown that the helium line and the N_2^+ band head (it is rather narrow) are well separated. In this scan the width of the split system was set at 4 Å° full width. As a control the scan was repeated with ultrapure helium. The nitrogen peak disappeared completely.

The gain of the system is set rather low in Fig. 2 due to the large amplitude in the helium peak. Figure 3 shows a scan with the gain set high enough to make the N_2 peak nearly full scale. It is seen that at this level of signal there is a very low level of background. It is believed that this signal is sufficiently clean to clearly set an alarm level in the range of 1-5 ppm (by volume).

To date the alarm circuitry has not been built nor has the flow system been set up to lower the contamination levels to a few parts per million.

There are several other candidates for the nitrogen indicator. The most likely one is an intense portion of the N_2 (neutral) band system at 3556-3580 Å° (called N_2 second positive, $^3\Pi \rightarrow ^3\Pi$,

see reference 1). Figure 4 shows a scan in this region. The nearest helium activity appears at 3381 A°. The slits were set at 4 A° full width in this scan. This system has greater separation from helium activity but not as much signal as the 3914 system.

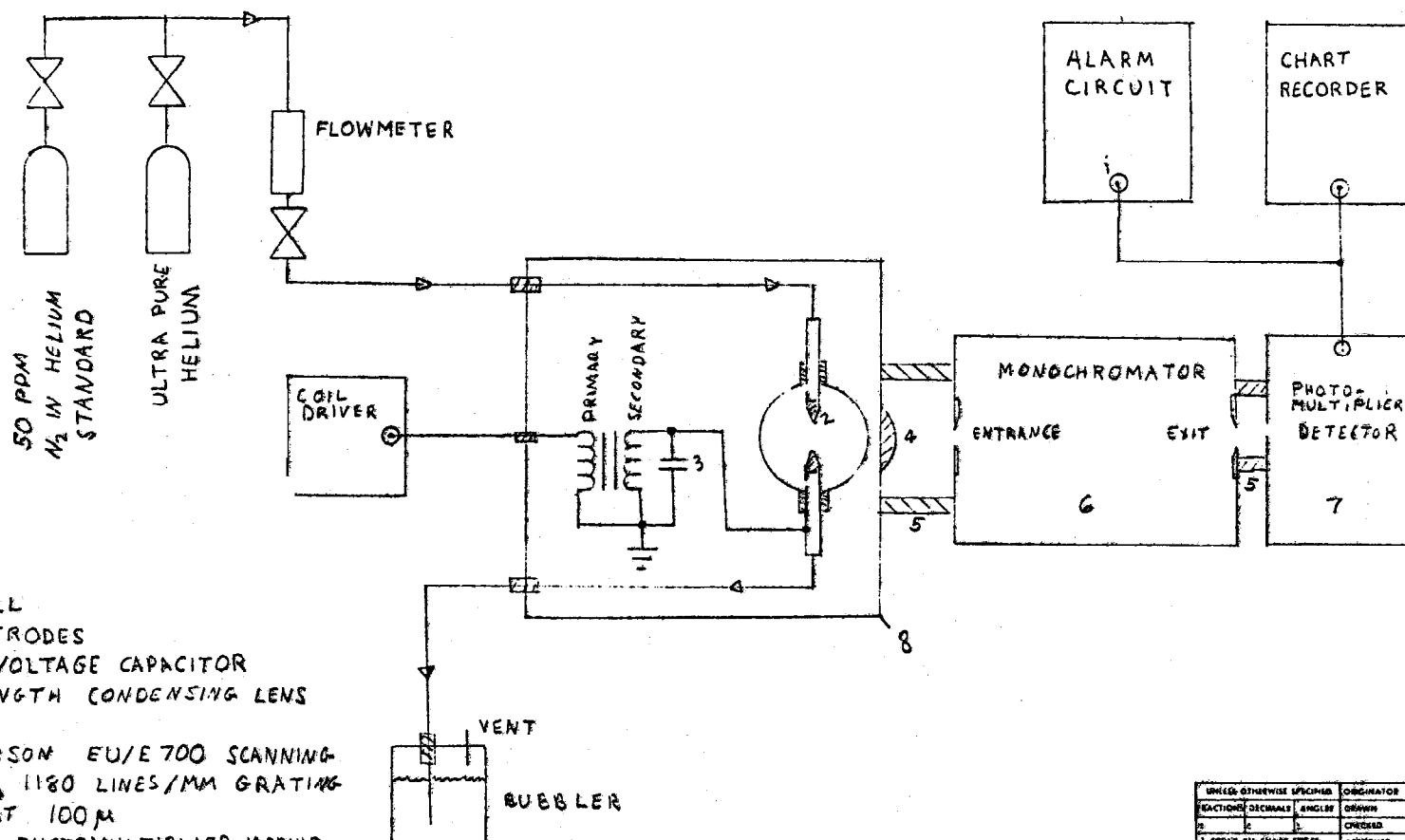
As a future development the system can be simplified once the wavelengths are firmly chosen and the excitation has been optimized. The simplification would be to use a fixed wavelength transmission system rather than a scanning system. This could consist of a fixed angle grating or an interference band pass filter. These ideas will be developed further.

In conclusion, it appears that the spectrographic system described here can readily detect and alarm on a N₂ contamination level of 1 ppm in a helium process stream. This indicator is continuous and responds quickly.

Furthermore, the technique should be applicable to other gases such as finding Ne or H₂ in helium, finding N₂ in H₂, or similar mixtures of a small contamination in another gas. It should also be possible to install the light source directly in the process stream to avoid confusion of contamination arising in sensing lines.

¹G.Hertzberg, "Molecular Spectra and Molecular Structure", Vol. 1, Spectra of Diatomic Molecular, 2nd ed., D.VanNostrand Co., Inc., New York, N.Y. (1950)

FIG 1 OVERALL PLAN FOR
SPECTROGRAPHIC NITROGEN
DETECTOR SYSTEM



NOTES

1. QUARTZ GAS CELL
2. TUNGSTEN ELECTRODES
3. 30000 PF HIGH VOLTAGE CAPACITOR
4. 35mm FOCAL LENGTH CONDENSING LENS
5. LIGHT SEAL
6. GCA / McPHERSON EU/E 700 SCANNING-MONOCHROMATOR, 1180 LINES/MM GRATING SLITS ARE SET AT 100μ
7. GCA / McPHERSON PHOTOMULTIPLIER MODULE MODEL EU-701-30
8. ALUMINUM LIGHT BOX, IMAGE OF LIGHT SOURCE IS FORMED ON MONOCHROMATOR ENTRANCE SLIT BY LENS 4.

UNLESS OTHERWISE SPECIFIED		ORIGINATOR		A. J. J. J. J.	
SECTION	DETAILED	ENGINEER	DESIGN	DATE	11-17
2	C		CHIEF		
1. BREAK ALL SHARP CORNERS TO RADIUS			APPROVED		
2. DO NOT SCALE DIMS.			USED ON		
3. DIMENSIONS IN PARENTHESES ARE TO BE USED WHEN THIS STANDARD IS USED FOR MATERIAL			MATERIAL		
FERMI NATIONAL ACCELERATOR LABORATORY ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION					
NITROGEN DETECTOR SYSTEM					
SCALE	FILMS	DRAWING NUMBER			REV.
NTS					



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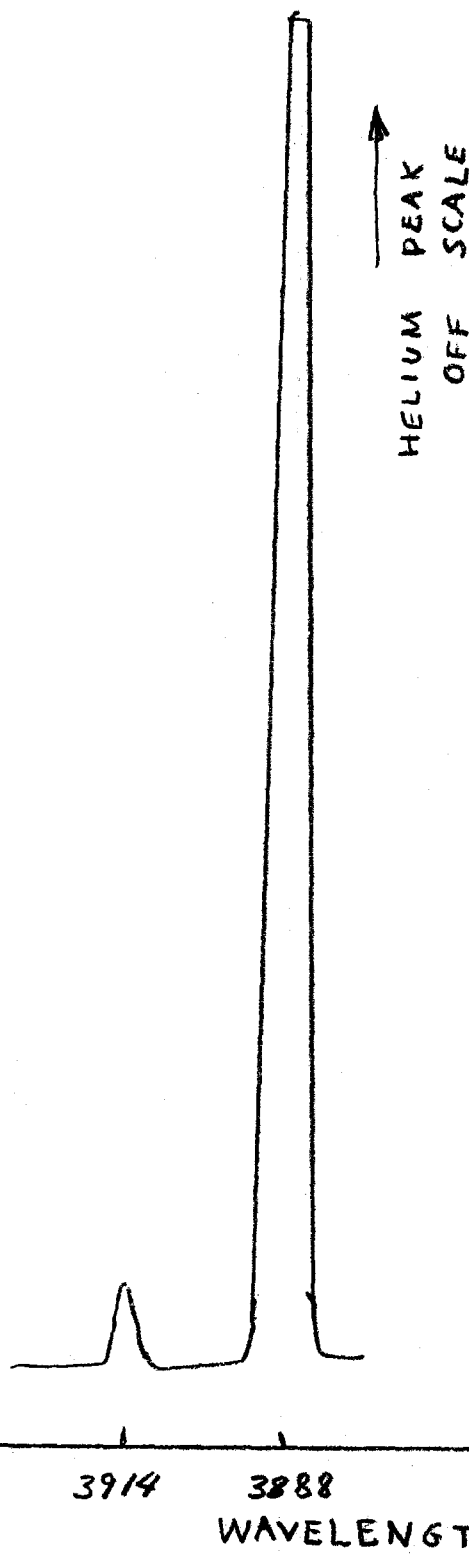


FIG 2. LOW GAIN SCAN IN REGION OF
3914 Å N_2^+ BAND, $^2\Sigma \rightarrow ^2\Sigma$
SLITS AT 4 Å FULL WIDTH



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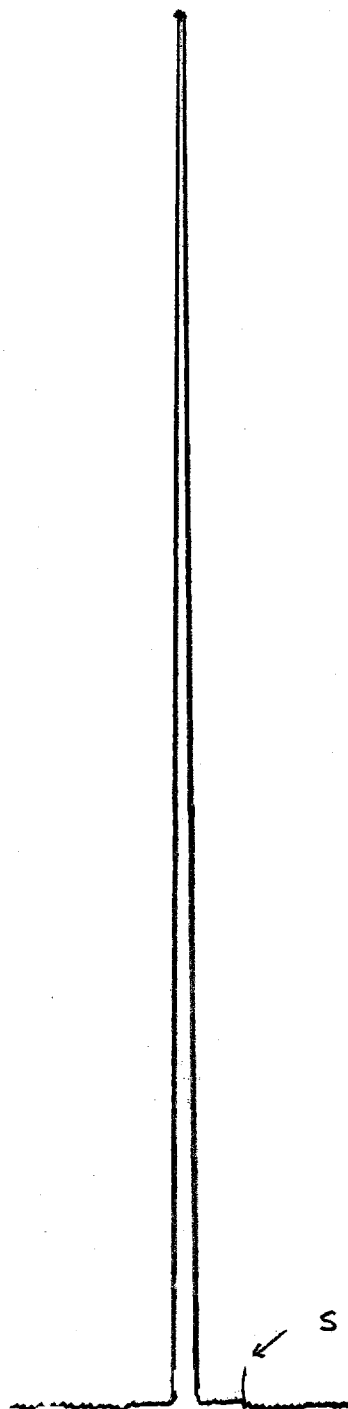


FIG. 3

HIGH GAIN SCAN
IN REGION OF 3914

N_2^+ BAND $2\Sigma \rightarrow 2\Sigma$

SLITS AT 2Å FULL WIDTH

START SCAN 3903Å

3914

WAVELENGTH Å